



Robert Whited

## Failure Analysis of 3D Printed Parts

Pathways Intern Start Date: January 2016

Graduation date: May 2017

University: The University of Alabama

Degree: Mechanical Engineering

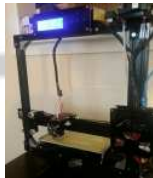
### Organization

- Launch Service Program
- Flight Structures Branch
- Stress/Strength Group

### Job Description

- Conduct Structural Analysis for Components
- Ensure Hardware Capability Exceed Design Requirements
- Participate in Structural Tests
- Support Hardware Acceptance Reviews

### Equipment and Material

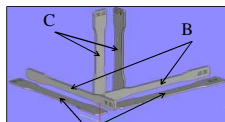


Anet A2 Aluminum  
Metal 3D Printer

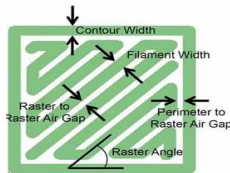


Polylactic Acid (PLA)  
Diameter: 1.75 mm

### Print Terminology



Print Orientation



Print Layout

### Does Layer Thickness Matter?

- Layers Thickness = Resolution



2 mm layer  
thickness



1 mm layer  
thickness

### Testing the Properties

ASTM-D638 Tensile Test  
Properties of Plastic



ASTM-D790 Flexural  
Properties of Plastic Materials

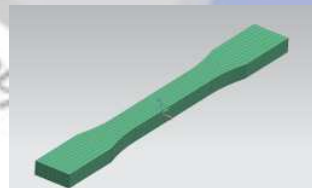


### How does orientation and layer thickness influence the material properties?

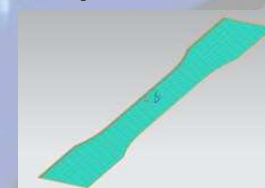
Young's Modulus (E)			
Layer Thickness	Orientation	Avg (Ksi)	Avg (Ksi)
.2	A	410.144	
.2	B	455.446	412.410
.2	C	371.641	
.1	A	345.138	
.1	B	367.532	377.49
.1	C	419.813	

Tensile strength Ultimate		
Layer Thickness	Orientation	Avg (Ksi)
.2	A	7.28
.2	B	7.86
.2	C	3.98
.1	A	6.62
.1	B	6.67
.1	C	5.27

### How to model 3D printed parts?

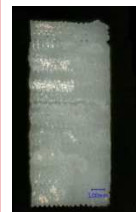


Isotropic-having identical values  
of a property in all directions



Orthotropic-material properties change  
when measured from different directions

### Is there a difference in the internal structure?



S-A .1mm



S-B .1mm



S-B .2mm

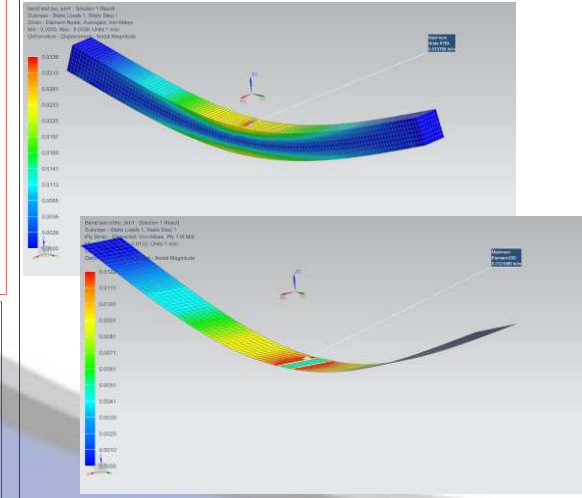


S-C .1mm



S-C .2mm

### Bend test



### Which model predicts failure better?

	Sample B.1-2	ISO solid	Ortho Shell
Load	130 lbf	130 lbf	130 lbf
Stress Actual	12847.91 psi	-----	-----
Stress Model	-----	12534.8 psi	12425.5 psi
Percent difference	----	2.432 %	3.281 %
Strain at failure Actual	.0353 in/in	-----	-----
Strain at Failure Model	-----	.0337 in/in	.0122 in/in
Percent difference	----	4.533 %	65.4 %**

\*\* Additional information is needed to help with the accuracy of this model.

### Acknowledgements

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- 1) Karl Thal: My Outstanding Mentor
- 2) Serkan Bastug, Jason Schmidt, Latife Kuguoglu for always taking the time to answer ALL of my questions
- 3) My supervisor Vipul Patel for giving me a chance
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